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# EXPLORATORY KRAFT AND NSSC PULPING OF MIXTURES OF 50 PHILIPPINE HARDWOODS

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UNITED STATES DEPARTMENT OF AGRICULTURE
FOREST SERVICE
In Cooperation with the University of Wisconsin

# EXPLORATORY KRAFT AND NSSC PULPING OF MIXTURES OF 50 PHILIPPINE HARDWOODS

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## Summary

Kraft pulps, with quality equal to or better than those from North American hardwood kraft pulps, were made using three chip mixtures of 50 Philippine hardwood species. Air classification of the wood chip mixtures can further improve the quality of the kraft pulps. Repeated recycling of the black liquor in kraft pulping did not appear to cause detrimental effects to either the liquors or the pulps. High-yield kraft pulping with 25-30 percent screenings for use in the manufacture of corrugating medium appears to be a feasible method of producing both corrugating medium and linerboard with only one pulping process. Neutral sulfite semichemical pulps made from the mixtures appears to be suitable for the manufacture of corrugating medium.

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[1] Maintained in Madison, Wis. in cooperation with the University of Wisconsin.

## Experimental

### Log Processing and Makeup of Mixtures

Fifty different species, with a total dry weight of about 10,000 pounds, were harvested in the Philippines. This wood resource covered a range of densities and colors as well as some heavy with silica and extractives. These logs were shipped to the Forest Products Laboratory (FPL) via air freight in order to prevent biological deterioration. Upon receipt of the logs by the Laboratory they were immediately placed into cold storage, where they, and the chips produced, remained until needed for further processing. A 1-foot length was cut from the butt log of each species to provide material for botanical studies and slabs for particleboard studies. One-inch disks were also cut from each log for the determination of specific gravity. The identification of each species was also verified.

All of the logs were peeled and converted into nominal 5/8-inch chips keeping each individual species separate. The bark was used in another study to determine fiber yield and other potential uses. The chips were screened and the oversize (+1-1/4-inch) and the undersize (-1/4-inch) were used in the fiberboard study. Samples of chips from each species were analyzed for ash and silica. Mixtures of the screened chips were made to simulate three potential naturally occurring density distributions. Chemical analyses were made on samples of the three mixtures to determine ash, silica, pH, and extractives.

### Separation of Chip Mixtures

A major premise of this study was that the higher specific gravity woods could be separated from the mixtures to provide fuel for powering

the processing equipment with an expected improvement in the quality of the pulp from the remaining chips. Using an arbitrary specific gravity of 0.50 as the separation point, the three chip mixtures were air classified to obtain two weight fractions corresponding to the compositions of the mixtures.

In the production of mechanical pulp for newsprint, light-colored woods are required. Attempts made to classify the chips via color sorting were unsuccessful. One technique was based on transmitted light and the fluorescent nature of some woods caused the bright red chips to react the same as the light-colored chips. The other technique based on reflected light was able to separate the chips but only with strict control of chip size. This process would not be economical, however, because of the high equipment cost required to separate a relatively low value product such as wood chips.

## Kraft Pulping

Kraft pulps having less than 1 percent screenings were made using the three mixtures and the air-classified fractions from each mixture. A similar pulp was also made from one of the mixtures after removing the fines through a 3/8-inch screen. This was an unsuccessful attempt to improve pulp quality by eliminating some of the higher density woods which had a tendency to produce smaller particles during chipping.

Kraft digestions were also made using the three mixtures to yield pulps having 25-30 percent screenings. These pulps were made to determine the feasibility of using the screened pulp for linerboard and the screenings for corrugating medium. The screenings were refined to about 250 Canadian Standard freeness in a 12-inch diameter, single-rotating disk mill and made into handsheets having a basis weight of 26 pounds/1000 ft.$^2$.

Because the high silica and extractives contents could possibly cause mill operating problems, a series of kraft digestions were made using one mixture containing 0.28 percent $SiO_2$ and this same mixture enriched to 1 percent $SiO_2$ with two high-silica containing species. A series of four digestions were made with the two mixtures and, with the exception of the first digestion, one-half of the total liquor volume was black liquor recycled from the previous digestion. The black liquors were analyzed for active alkali, total solids, ash, silica, tall oil, and calorific value. The pulps were analyzed for kappa number, ash, silica, and petroleum ether and methyl alcohol extractives.

## NSSC Pulping

NSSC pulping conditions were established to produce pulps with yields of about 75 percent from each mixture. These pulps were refined to about 250 Canadian Standard freeness in a 12-inch diameter, single-rotating disk mill and made into handsheets having a basis weight of 26 pounds/1000 ft.$^2$.

# Results

## Properties of Individual Species and Mixtures

Given in Table 1 are the specific gravity, ash, and silica contents of the individual species. The specific gravity ranged from a low of 0.236 to a high of 0.793. Ash contents ranged from 0.09 to 5.21 percent while silica contents ranged from none to a high of 4.55 percent.

The amounts of the individual species in the three mixtures are given in Table 2. Mixture "A" contains an even distribution of all species while mixture "B" is weighted with more of the high-density species and mixture "C"

is weighted with more of the intermediate density species. The weighted average specific gravity of the three mixtures is 0.505, 0.643, and 0.538, respectively.

As shown in Table 3, there were only small differences in the amounts of ash and extractives in the three mixtures. A larger difference was found in the amount of silica, however, which ranged from 0.12 to 0.28 percent.

## Air Classification of Chip Mixtures

The three mixtures, "A," "B," and "C," contained 48, 15, and 33 percent chips having a specific gravity of less than 0.5. The amount of air passing through the air classifier was adjusted to obtain these respective amounts of chips in the light fractions. As shown in Table 4, the actual amounts obtained in the light fractions was very close to those amounts desired. Samples of the chips in both the light and the heavy fractions were identified to determine the efficiency of separation which is defined as the percentage of desirable chips in that fraction. The average efficiency for all six fractions was nearly 80 percent.

## Kraft Pulp Quality

As shown in Table 5, similar yields and kappa numbers were obtained from all three mixtures pulped under the same conditions. The heavy fractions obtained via air classification appear to be slightly more difficult to pulp than the corresponding light fractions as evidenced by their larger amounts of screenings and higher kappa numbers.

There were only small differences in the quality of the fully cooked kraft pulps made from the three mixtures (Table 6). The strength properties of these pulps were equal to or better than those of North American hardwood

kraft pulps and comparable to previous results found with mixtures of tropical hardwoods from Colombia and Venezuela. The screened pulps from the digestions made to give high percentages of screenings had bursting and tensile strengths only slightly less than those of the fully cooked kraft pulps but had a loss in tearing resistance of about 10 percent. Larger pulp quality differences were found when pulps from the air-separated fractions are compared. The pulps made from the fractions containing chips having a specific gravity of less than 0.5 had 10-20 percent higher bursting and tensile strengths and 10-20 percent lower tearing resistance compared to the pulps made from the fractions containing chips greater than 0.5 specific gravity. Thus, air classification is one viable means of improving the quality of pulps from mixed tropical hardwoods.

Effect of Black Liquor Recycle

As shown in Table 7, equilibrium appears to be reached with only three to four recyclings of the black liquor. With both wood mixtures, the black liquors leveled off at about 23 percent total solids and about 9.4 percent ash. The amount of silica in the black liquors from the two wood mixtures was different, however. The black liquor from the lower silica wood mixture leveled off at about 0.08 percent $SiO_2$ while the liquor from the higher silica mixture leveled off at about 0.15 percent $SiO_2$. The amounts of tall oil in the liquors was negligible and no increasing trend was found. The calorific values of the black liquors from the fourth digestion of each mixture were 6562 BTU/pound of solids for the lower silica wood mixture and 6832 BTU/pound of solids for the higher silica wood mixture.

The total pulp yield, screenings, and kappa numbers remained constant throughout each series of digestions. However, more screenings were

obtained from the higher silica mixture. The pulps from both series of digestions all had about 1.3 percent ash while the amount of silica in the pulps from the lower silica mixture was about 0.08 percent $SiO_2$ and those from the higher silica mixture was about 0.30 percent $SiO_2$. The amount of extractives in the pulps was negligible and no increasing trend was found.

## Quality of NSSC and Kraft Screenings Pulps

The conditions and results of the NSSC digestions of the three mixtures are given in Table 8. As was found in kraft pulping, the differences between the three mixtures in their response to pulping are small.

Based on handsheets made from these small-scale digestions (Table 9), it appears that acceptable quality corrugating medium can be made from any of the mixtures cooked by either the NSSC or the kraft process. This is being verified by actually making corrugating medium on the paper machine and conversion into boxes in another study.

## Conclusions

1. The strength properties of the kraft pulps made from all three mixtures were equal to or better than those of North American hardwood kraft pulps.

2. Within the wood specific gravity range studied, the differences in both the NSSC and kraft pulpability of the three mixtures are small.

3. Air classification of mixed tropical hardwood chips appears to be a viable means for improving pulp quality.

4. Recycling of the black liquors does not appear to build up an excessive amount of silica or extractives in either the black liquors or the kraft pulps.

5. It appears that acceptable quality corrugating medium can be made from all three of the mixtures cooked to 75 percent yield by the NSSC process.

6. High-yield kraft pulping with 25-30 percent screenings for use in the manufacture of corrugating medium appears to be a feasible method of producing both linerboard and corrugating medium with only one pulping process.

Table 1.--Specific Gravity, Ash, and Silica Content of 50 Philippine Woods

| | Species | | Specific gravity | | Ash | Silica |
|---|---|---|---|---|---|---|
| | Common name | Latin name | Previously published | Forest Products Laboratory | | |
| | | | | | Pct. | Pct. |
| | Tangisang-bayauak | Ficus variegata | 0.28 | 0.236 | 3.64 | 0.02 |
| | Binuang | Octomeles sumatrana | .37 | .242 | 1.32 | 0 |
| | Kapok | Ceiba pentandra | .23 | .244 | 4.45 | 0 |
| | Balilang-uak | Meliosma macrophylla | .27 | .260 | 1.34 | .04 |
| | Rarang | Erythrina subumbrans | .24 | .264 | 1.61 | 0 |
| | Kaitana | Zanthoxylum rhetsa | .33 | .296 | .75 | < .01 |
| | Ilang-ilang | Cananga odorata | .29 | .308 | 1.46 | .02 |
| | Gubas | Endospermum peltatum | .31 | .316 | .62 | < .01 |
| | Dita | Alstonia scholaris | .36 | .316 | 1.08 | .01 |
| 0 | Anabiong | Trema orientalis | .31 | .319 | 1.00 | 0 |
| 1 | Hamindang | Macaranga bicolor | .29 | .324 | 1.46 | .02 |
| 2 | Balanti | Homalanthus populneus | .38 | .356 | 1.17 | < .01 |
| 3 | Mayapis | Shorea squamata | .39 | .366 | .36 | .04 |
| 4 | Matang-arau | Melicope triphylla | .37 | .381 | 1.05 | .43 |
| 5 | Malasantol | Sandoricum vidalii | .43 | .394 | .61 | .01 |
| 6 | White lauan | Pentacme contorta | .44 | .401 | .72 | .06 |
| 7 | Tulo | Alphitonia philippinensis | .40 | .422 | .47 | < .01 |
| 8 | Tangile | Shorea polysperma | .46 | .429 | .20 | .08 |
| 9 | Pahutan | Mangifera | .55 | .435 | 2.91 | .02 |
| 0 | Apanit | Mastixia philippinensis | .47 | .447 | 1.72 | .10 |
| 1 | Lago | Pygeum vulgare | .57 | .451 | .50 | < .01 |
| 2 | Antipolo | Artocarpus blancoi | .41 | .469 | 5.21 | 4.55 |

Table 1.--Specific Gravity, Ash, and Silica Content of 50 Philippine Woods--con.

| | Species | | Specific gravity | | Ash | Silica |
|---|---|---|---|---|---|---|
| | Common name | Latin name | Previously published | Forest Products Laboratory | | |
| | | | | | Pct. | Pct. |
| 3 | Bagtikan | Parashorea plicata | 0.51 | 0.478 | 1.42 | < .01 |
| 4 | Sakat | Terminalia nitens | .56 | .485 | .68 | .10 |
| 5 | Red lauan | Shorea negrosensis | .44 | .510 | .09 | .03 |
| 6 | Itangan | Weinmannia luzoniensis | .49 | .526 | 1.52 | < .01 |
| 7 | Piling-liitan | Canarium luzonicum | .49 | .549 | .73 | .21 |
| 8 | Palosapis | Anisoptera thurifera | .51 | .554 | 1.17 | .72 |
| 9 | Lomarau | Swintonia foxworthyi | .63 | .559 | 1.00 | .10 |
| 30 | Malabetis | Madhuca oblongifolia | .53 | .560 | 3.01 | 2.19 |
| 31 | Dangkalan | Calophyllum obliquinervium | .58 | .568 | .65 | < .01 |
| 32 | Panau | Dipterocarpus gracilis | .61 | .576 | .93 | .43 |
| 33 | Katmon | Dillenia philippinensis | .68 | .592 | 1.06 | .02 |
| 34 | Batitinan | Lagerstroemia piriformis | .49 | .597 | 3.56 | .01 |
| 35 | Katong-lakihan | Amoora macrophylla | .54 | .608 | .84 | .03 |
| 36 | Narig | Vatica mangachapoi | .68 | .618 | .74 | .22 |
| 37 | Miau | Dysoxylum euphlebium | .63 | .623 | 1.16 | .04 |
| 38 | Apitong | Dipterocarpus grandiflorus | .62 | .623 | .69 | .23 |
| 39 | Bok-bok | Xanthophyllum excelsum | .63 | .639 | 1.11 | 0 |
| 40 | Kamatog | Erythrophloeum densiflorum | .67 | .650 | 1.62 | .01 |

Table 1.--Specific Gravity, Ash, and Silica Content of 50 Philippine Woods--con.

| | Species | | Specific gravity | | Ash | Silica |
|---|---|---|---|---|---|---|
| | Common name | Latin name | Previously published | Forest Products Laboratory | | |
| | | | | | Pct. | Pct. |
| 41 | Dalingdingan | Hopea foxworthyi | 0.62 | 0.667 | 0.70 | 0.04 |
| 42 | Katilma | Diospyros nitida | .71 | .679 | 2.51 | .02 |
| 43 | Yakal | Shorea astylosa | --- | .718 | .92 | .03 |
| 44 | Kamagong | Diospyros philippinensis | .78 | .720 | 2.98 | < .01 |
| 45 | Katong-matsin | Chisocheton pentandrus | .52 | .725 | .78 | .02 |
| 46 | Manaring | Lithocarpus soleriana | .63 | .736 | .79 | .02 |
| 47 | Ipil-ipil | Leucaena leucocephala | .73 | .737 | .91 | .01 |
| 48 | Bolong-eta | Diospyros pilosanthera | .81 | .743 | 1.96 | .02 |
| 49 | Makaasim | Syzygium nitidum | .75 | .778 | .78 | .03 |
| 50 | Alupag-amo | Litchi philippinensis | .89 | .793 | 1.10 | < .01 |

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Table 2.--Composition of Three Chip Mixtures of 50 Philippine Hardwoods

| Species[1] | Specific gravity range | Mixture composition[2] | | |
|---|---|---|---|---|
| | | A | B | C |
| | | Pct. | Pct. | Pct. |
| 1-6 | 0.236-.296 | 16.67 | 2 | 4 |
| 7-15 | .308-.394 | 16.67 | 4 | 8 |
| 16-24 | .401-.485 | 16.67 | 9 | 20 |
| 25-34 | .510-.597 | 16.67 | 15 | 40 |
| 35-42 | .608-.679 | 16.67 | 20 | 20 |
| 43-50 | .718-.793 | 16.67 | 50 | 8 |

[1] See Table 1 for names of the individual species.

[2] Moisture-free wood basis.

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Table 3.--Chemical Analysis of Chip Mixtures

| Mixture | pH | Ash[1] | $SiO_2$[1] | Extractives[1] | | |
|---|---|---|---|---|---|---|
| | | | | Ethyl ether | Alcohol-benzine | Hot water |
| | | Pct. | Pct. | Pct. | Pct. | Pct. |
| A | 5.37 | 1.45 | 0.19 | 0.76 | 4.14 | 3.45 |
| B | 5.09 | 1.38 | .12 | .91 | 4.05 | 3.28 |
| C | 5.06 | 1.39 | .28 | .75 | 3.78 | 3.05 |

[1] Moisture-free wood basis.

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Table 4.--Air Classification of Chip Mixtures

| ixture | Light fraction[1] | | | Heavy fraction[2] | | |
|---|---|---|---|---|---|---|
| | Quantity | | Efficiency[3] | Quantity | | Efficiency[3] |
| | In mixture | Obtained | | In mixture | Obtained | |
| | Pct. | Pct. | Pct. | Pct. | Pct. | Pct. |
| A | 48.0 | 50.0 | 80.0 | 52.0 | 50.0 | 76.0 |
| B | 15.0 | 15.4 | 69.2 | 85.0 | 84.6 | 92.3 |
| C | 33.0 | 31.9 | 80.0 | 67.0 | 68.1 | 72.0 |

ess than 0.5 specific gravity.

reater than 0.5 specific gravity.

ercentage of desirable chips in that fraction.

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Table 5.--Kraft Pulping[1] of Mixtures of Philippine Hardwoods

| Mixture fraction | Digestion No. | Time at 170° C. | Black liquor NaOH ($Na_2O$) | Black liquor $Na_2S$ ($Na_2O$) | Yield[2] Total | Yield[2] Screenings (10-cut) | Kappa No. |
|---|---|---|---|---|---|---|---|
| | | Min. | G./l. | G./l. | Pct. | Pct. | |
| MIXTURE A | | | | | | | |
| Whole | 5890X | 90 | 2.2 | 7.2 | 47.5 | 0.9 | 29.6 |
| Whole | 5900X | 30 | 4.3 | 8.7 | 49.2 | 5.6 | ---- |
| Whole | 5906X | 17 | 5.1 | 8.4 | 52.6 | 22.6 | 48.7 |
| Lights[3] | 5918X | 90 | 2.4 | 7.8 | 49.3 | .4 | 23.3 |
| Heavies[4] | 5921X | 90 | 2.2 | 8.8 | 46.8 | .9 | 24.9 |
| MIXTURE B | | | | | | | |
| Whole | 5891X | 90 | 2.1 | 7.9 | 47.5 | .9 | 29.1 |
| Whole | 5901X | 30 | 4.1 | 8.9 | 48.8 | 8.3 | ---- |
| Whole | 5907X | 20 | 5.2 | 9.3 | 51.1 | 21.1 | 47.6 |
| Less 3/8-inch fraction | 5912X | 90 | 2.0 | 9.5 | 46.4 | ..8 | 24.2 |
| Lights[3] | 5920X | 90 | 4.4 | 3.1 | 47.2 | .3 | 22.5 |
| Heavies[4] | 5922X | 90 | 2.1 | 9.0 | 46.7 | .9 | 24.9 |
| MIXTURE C | | | | | | | |
| Whole | 5892X | 90 | 1.5 | 8.0 | 48.0 | .9 | 27.8 |
| Whole | 5902X | 30 | 4.4 | 10.6 | 51.0 | 10.6 | ---- |
| Whole | 5917X | 15 | 4.9 | 9.1 | 52.7 | 24.0 | 47.3 |

[1]Constant conditions used were 16.0 percent active alkali, 25 percent sulfidity, 4-to-1 liquor-to-wood ratio, and 90 minutes rise 80-170° C.

[2]Moisture-free wood basis.

[3]Air classified, less than 0.5 specific gravity.

[4]Air classified, greater than 0.5 specific gravity.

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Table 6.--Properties of Kraft Pulps Made From Mixtures of Philippine Hardwoods

| Mixture fraction | Digestion No. | Pulp properties: Kappa No. | Pulp properties: Average fiber length | Pulp properties: Coarseness | Pulp properties: Fibers/gram | Handsheet properties: Freeness (Canadian Standard) | Handsheet properties: Beating time | Handsheet properties: Burst factor | Handsheet properties: Tear factor | Handsheet properties: Breaking length | Handsheet properties: Apparent density |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Mm. | Mg./100 M. | $x\ 10^5$ | Ml. | Min. | | | Km. | G./cc. |
| MIXTURE A | | | | | | | | | | | |
| Whole | 5890X | 29.6 | 1.23 | 13.1 | 75.9 | 645 | 0 | 22.9 | 133.6 | 5.9 | 0.51 |
| | | | | | | 550 | 18 | 52.5 | 136.5 | 9.3 | .59 |
| | | | | | | 350 | 48 | 72.5 | 131.0 | 11.8 | .67 |
| Whole | 5906X | 48.7 | ---- | ---- | ---- | 700 | 0 | 16.6 | 82.0 | 4.2 | .49 |
| | | | | | | 550 | 17 | 49.5 | 114.0 | 9.2 | .57 |
| | | | | | | 350 | 35 | 68.0 | 116.5 | 11.0 | .66 |
| Lights | 5918X | 23.3 | ---- | ---- | ---- | 645 | 0 | 28.9 | 125.6 | 6.3 | .55 |
| | | | | | | 550 | 14 | 63.5 | 124.5 | 10.4 | .64 |
| | | | | | | 350 | 40 | 86.0 | 116.0 | 12.5 | .72 |
| Heavies | 5921X | 24.9 | ---- | ---- | ---- | 675 | 0 | 21.0 | 128.6 | 4.6 | .50 |
| | | | | | | 550 | 21 | 57.0 | 136.0 | 9.1 | .58 |
| | | | | | | 350 | 41 | 71.5 | 130.0 | 11.0 | .65 |
| MIXTURE B | | | | | | | | | | | |
| Whole | 5891X | 29.1 | 1.35 | 11.7 | 87.7 | 675 | 0 | 14.7 | 88.5 | 4.5 | .46 |
| | | | | | | 550 | 25 | 46.0 | 134.0 | 8.7 | .57 |
| | | | | | | 350 | 55 | 66.5 | 139.0 | 10.8 | .65 |
| Whole | 5907X | 47.6 | ---- | ---- | ---- | 710 | 0 | 11.3 | 65.0 | 3.6 | .46 |
| | | | | | | 550 | 20 | 43.0 | 124.0 | 8.7 | .56 |
| | | | | | | 350 | 37 | 59.0 | 129.0 | 10.3 | .61 |
| Whole less 3/8-inch fraction | 5912X | 24.2 | ---- | ---- | ---- | 680 | 0 | 21.6 | 97.5 | 5.1 | .50 |
| | | | | | | 550 | 18 | 42.0 | 135.0 | 8.0 | .57 |
| | | | | | | 350 | 38 | 66.5 | 134.5 | 10.7 | .65 |
| Lights | 5920X | 22.5 | ---- | ---- | ---- | 660 | 0 | 24.8 | 128.6 | 6.0 | .54 |
| | | | | | | 550 | 18 | 52.0 | 126.0 | 9.4 | .63 |
| | | | | | | 350 | 41 | 75.0 | 120.0 | 11.4 | .68 |
| Heavies | 5922X | 24.9 | ---- | ---- | ---- | 680 | 0 | 19.8 | 80.8 | 4.8 | .48 |
| | | | | | | 550 | 21 | 47.5 | 131.5 | 8.3 | .58 |
| | | | | | | 350 | 42 | 66.0 | 137.0 | 10.2 | .64 |
| MIXTURE C | | | | | | | | | | | |
| Whole | 5892X | 27.8 | 1.39 | 13.1 | 76.3 | 675 | 0 | 21.5 | 114.8 | 6.0 | .52 |
| | | | | | | 550 | 33 | 57.5 | 139.0 | 9.9 | .61 |
| | | | | | | 350 | 57 | 73.0 | 136.0 | 11.5 | .66 |
| Whole | 5917X | 47.3 | ---- | ---- | ---- | 740 | 0 | 7.6 | 50.7 | 2.1 | .40 |
| | | | | | | 550 | 28 | 47.0 | 114.0 | 8.0 | .59 |
| | | | | | | 350 | 41 | 64.0 | 116.0 | 9.8 | .64 |

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Table 7.--Effect of Black Liquor Recycle in Kraft Pulping

| gestion No. | Cycle No. | Black liquor | | | | | | | Pulp | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | NaOH ($Na_2O$) | $Na_2S$ ($Na_2O$) | Solids[1] | Ash[1] | $SiO_2$[1] | Tall oil[1] | Calorific value | Yield[2] | | Kappa No. | Ash[3] | $SiO_2$[3] | Extractives[3] | |
| | | | | | | | | | Total | Screenings | | | | Petroleum ether | Methyl alcohol |
| | | G./l. | G./l. | Pct. | Pct. | Pct. | Pct. | BTU/lb. solids | Pct. | Pct. | | Pct. | Pct. | Pct. | Pct. |
| MIXTURE C (0.28 PCT. $SiO_2$) | | | | | | | | | | | | | | | |
| 937X | 1 | 1.5 | 8.9 | 14.69 | 6.19 | 0.05 | 0.02 | ---- | 47.2 | 0.6 | 23.1 | 1.14 | 0.08 | 0.18 | 0.65 |
| 941X | 2 | 2.1 | 11.1 | ----- | ---- | --- | .03 | ---- | 46.3 | .3 | 21.0 | 1.33 | .08 | .32 | .48 |
| 944X | 3 | 1.8 | 12.8 | 23.16 | 9.15 | .07 | .01 | ---- | 47.4 | .3 | 22.4 | 1.31 | .09 | .36 | .51 |
| 948X | 4 | 2.1 | 13.1 | 23.04 | 9.44 | .08 | .06 | 6562 | 47.3 | .3 | 22.4 | 1.35 | .07 | 0 | .41 |
| MIXTURE C ENRICHED WITH TWO HIGH-SILICA SPECIES (1.00 PCT. $SiO_2$) | | | | | | | | | | | | | | | |
| 936X | 1 | .9 | 9.0 | 14.66 | 6.16 | .08 | .02 | ---- | 46.7 | 1.4 | 21.6 | 1.29 | .30 | .12 | .65 |
| 940X | 2 | 2.3 | 11.0 | 19.91 | 8.21 | .15 | .05 | ---- | 48.0 | 1.3 | 22.5 | 1.46 | .32 | .20 | .62 |
| 943X | 3 | 2.0 | 11.7 | 21.86 | 8.96 | .13 | .02 | ---- | 47.2 | 1.5 | 21.2 | 1.29 | .29 | .34 | .63 |
| 947X | 4 | 1.6 | 12.9 | 22.92 | 9.35 | .14 | .05 | 6832 | 47.6 | 1.3 | 22.0 | 1.35 | .31 | .29 | .41 |

ased on weight of black liquor.

ased on moisture-free weight of wood.

ased on moisture-free weight of screened pulp.

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Table 8.--NSSC Pulping[1] of Mixtures of Philippine Hardwoods

| Digestion No. | $Na_2SO_3$ Initial concentration | $Na_2SO_3$ Final concentration | $Na_2SO_3$ Consumed | Spent liquor pH | Yield |
|---|---|---|---|---|---|
| | G./l. | G./l. | Pct. | | Pct. |
| | | MIXTURE A | | | |
| 2514Y | 65.1 | 18.7 | 9.8 | 8.7 | 74.9 |
| | | MIXTURE B | | | |
| 2515Y | 65.4 | 21.7 | 8.8 | 8.7 | 77.1 |
| | | MIXTURE C | | | |
| 2516Y | 68.2 | 19.8 | 10.1 | 8.6 | 76.4 |

[1] Constant conditions used were 16 percent $Na_2SO_3$, 4 percent $Na_2CO_3$, 3.5-to-1 liquor-to-wood ratio, 15 minutes steaming at 15 p.s.i.g., 120 minute rise from 80° to 175° C., and 60 minutes at 175° C.

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Table 9.--Handsheet Properties of NSSC Pulps and Screenings From High-Yield Kraft Pulps

| Mixture | Digestion No. | Freeness (Canadian Standard) | Basis weight | Thickness | Burst factor | Tear factor | Breaking length | Apparent density | Ring crush | Concora |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Ml. | Lb./1000 ft.$^2$ | Mils | | | M. | G./cc. | Lb. | Lb. |
| NEUTRAL SULFITE SEMICHEMICAL | | | | | | | | | | |
| A | 2514Y | 255 | 26.4 | 9.5 | 29.4 | 72.0 | 5490 | 0.48 | 63.8 | 68.6 |
| B | 2515Y | 250 | 26.3 | 10.6 | 27.9 | 73.5 | 5015 | .43 | 52.6 | 60.8 |
| C | 2516Y | 265 | 26.8 | 10.7 | 25.2 | 71.8 | 5015 | .43 | 56.8 | 58.8 |
| SCREENINGS FROM HIGH-YIELD KRAFT | | | | | | | | | | |
| A | 5906X | 250 | 26.4 | 8.9 | 40.5 | 112.4 | 6745 | .51 | 55.0 | 61.6 |
| B | 5907X | 250 | 25.5 | 9.5 | 34.1 | 97.4 | 5875 | .46 | 47.4 | 58.8 |
| C | 5917X | 265 | 26.2 | 8.5 | 37.1 | 101.0 | 6395 | .53 | 51.6 | 62.4 |

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